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Laser Scanned Image Sensors Using Photoconductors With Deep Traps

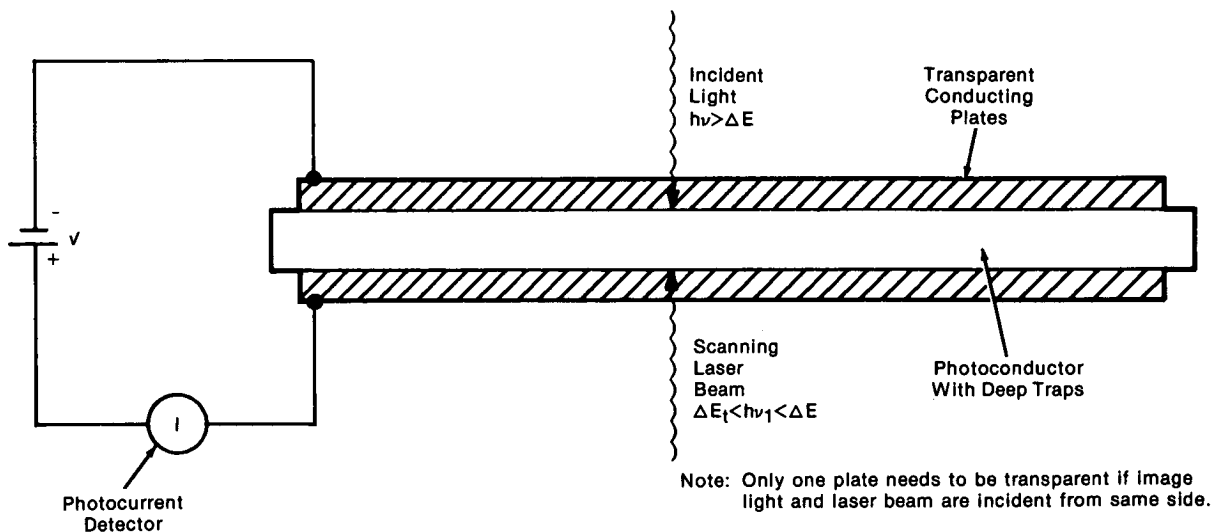
Improved image sensors used on TV cameras can be made with photoconductors containing deep traps for carriers, electrons and holes. Basically, the photoconductor records an image when the holes and the electrons are trapped inside it due to the incident photons. This image in the form of accumulated trapped carriers can be instantly read out by exposing the photoconductor to a scanning laser beam. Photons from the scanning laser empty the traps, generating a photocurrent. Image information is obtained by detecting this photocurrent synchronously with the laser scan.

A simplified diagram of the process is shown in the illustration. Photons of incident light from an image strike the photoconductor with energy $h\nu$ (where h is Planck's constant and ν is the frequency) greater than the band gap ΔE of the photoconducting semiconductor. The incident photons generate electron-hole pairs which are trapped in empty trap states. The process continues during the period of exposure,

typically a few seconds, until the accumulated trapped carriers have integrated the incident flux of photons.

The accumulation of trapped carriers (electrons and holes) is instantly read out by emptying the traps by exposure to a laser beam of photon energy $h\nu_1$, where $\Delta E_t < h\nu_1 < \Delta E$, and ΔE_t is the maximum trap energy. During the laser exposure, the photocurrent is released by maintaining a constant voltage bias across the photoconductor at all times during image sensing, using two parallel plate conducting contacts.

The process is analogous to conventional vidicons in that it integrates the image of incident photons in the form of an electrical charge and then senses the integrated charge. In conventional vidicons, the charge is normally stored on the opposite surface of the photoconductor (or photodiodes for a silicon vidicon). The charge then is read off at each point by a scanning electron beam. In the new process, the image is integrated in the form of trapped charge carriers which are released by the scanning laser



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(continued overleaf)

beam. The image is sensed through an electrical circuit. The laser can be scanned by nonmechanical means such as acoustic optic X-Y deflection systems.

The proposed method can improve the image sensors in several ways:

- a. High-energy electron optics used in standard image sensors can be eliminated. This avoids some serious reliability and failure problems, such as limited cathode life and the degradation of photo-sensitive material (particularly silicon in silicon vidicons) due to X-ray generation.
- b. Since no discrete structures (such as diode arrays) are needed and little lateral spread is anticipated, very high resolution may be obtained approaching fundamental optical limits.
- c. System sensitivity should be equivalent to the most sensitive vidicons (photon noise-limited) because of the same absorption mechanisms, leading to high quantum efficiency and the same kind of integrating feature.
- d. A wide choice of photoconductors is possible because of the minimal requirements on the band gap and the presence of deep traps. The preferred band gap is in the neighborhood of 1 to 2.5 eV. The upper limit is set by practical optical cutoff wavelengths; the lower limit is set by excessive dark currents due to thermal generation (unless cooled). Deep traps are easily introduced into semiconductors and often occur naturally.

- e. Finally, images may be stored for long times (hours) without cooling. The long storage time is required for transferring the image data to tapes.

Note:

Requests for further information may be directed to:

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Reference: TSP75-10112

Patent status:

This invention has been patented by NASA (U.S. Patent No. 3,865,975). Inquiries concerning non-exclusive or exclusive license for its commercial development should be addressed to:

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